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Solution-Processed Graphene for Flexible Triboelectric Nanogenerators

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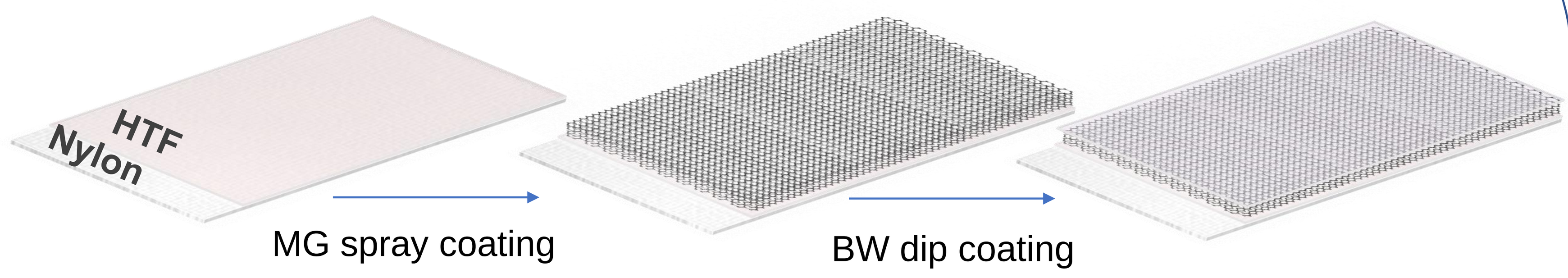
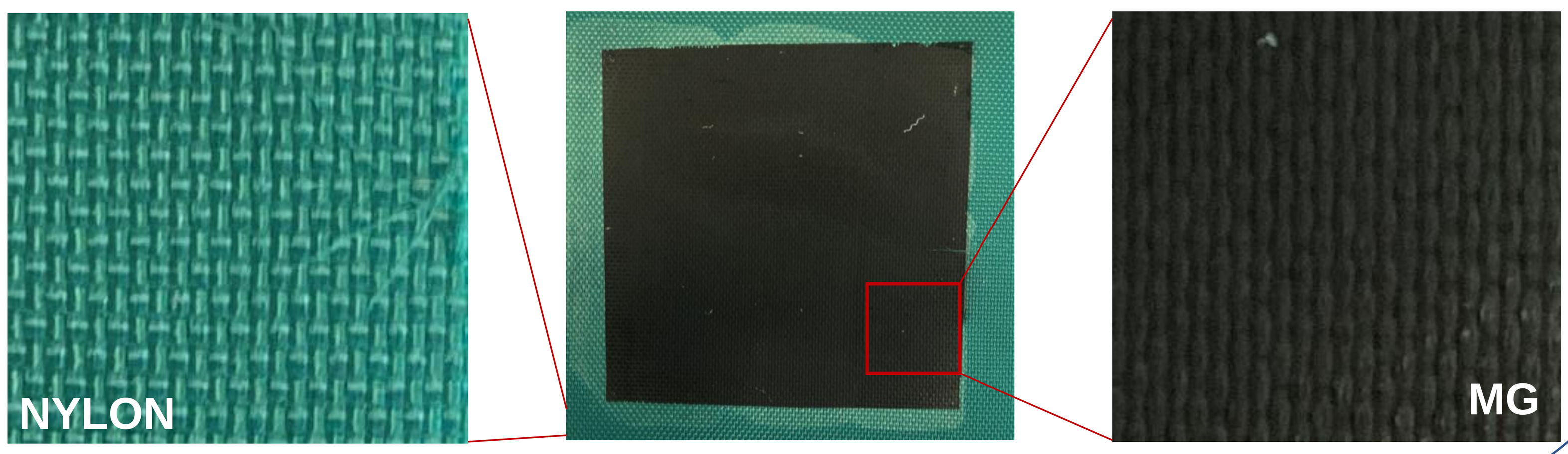
The rapid development of wearable technologies for healthcare or security applications has raised demanding requirements for portable and sustainable power sources. Flexible triboelectric nanogenerators (TENG) are found to be an appropriate wearable approach to combining body motions with vital signs monitoring. However, this technology is high-costly and suffers from low power output and unstable electric output values. Herein, we demonstrate flexible TENG integrated with shear force exfoliated multilayer graphene (MG). We also pioneered beeswax (BW) as an active triboelectric layer.

Schematic of the TENG fabrication

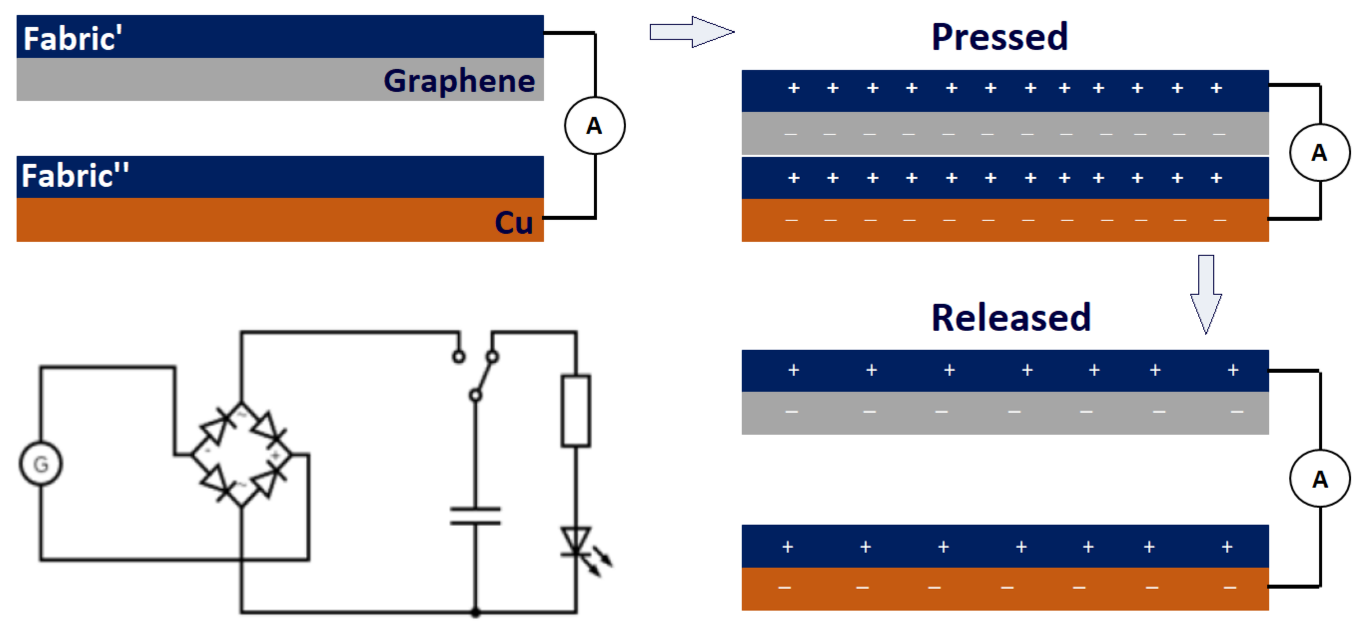


The MG was exfoliated in an ethanol-water mixture and spray-coated on a nylon substrate. The ML on nylon served as an electrode material. Further MG was coated with beeswax (BW) that served as an active triboelectric layer.

Digital images of MG on green nylon



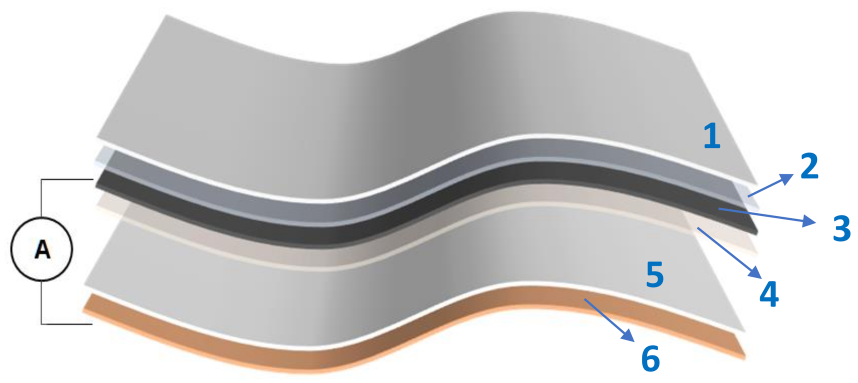
Working principle of triboelectric nanogenerator



TENG is a promising energy harvesting technology owing to its special ability to convert low-frequency mechanical energy to electrical energy. The working principle of TENG depends on the coupling effect of subsequent triboelectrification and electrostatic induction, which are based on the change in surface polarization of two materials that interact with each other.

Triboelectric response of as-fabricated TENG (size 1.5x2.5 cm) was tested with a cyclic physical stimulus (see the schematic of the circuit above).

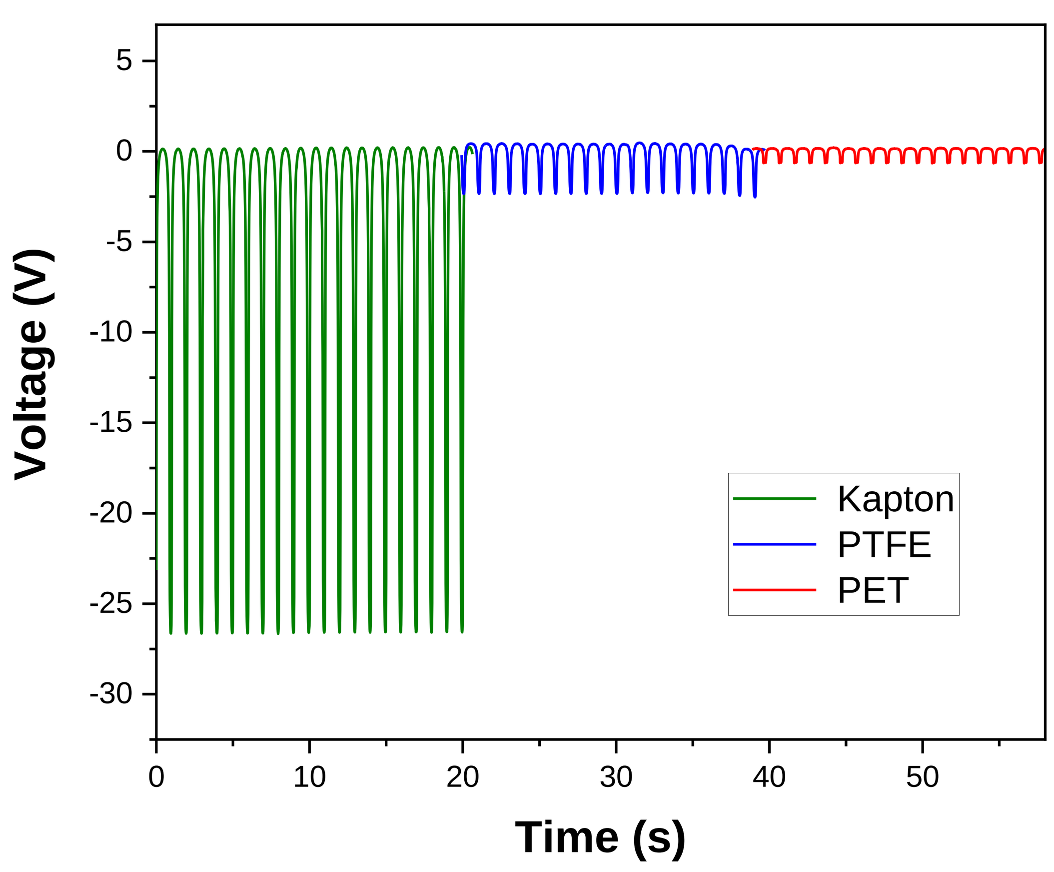
MG-enabled TENG structure



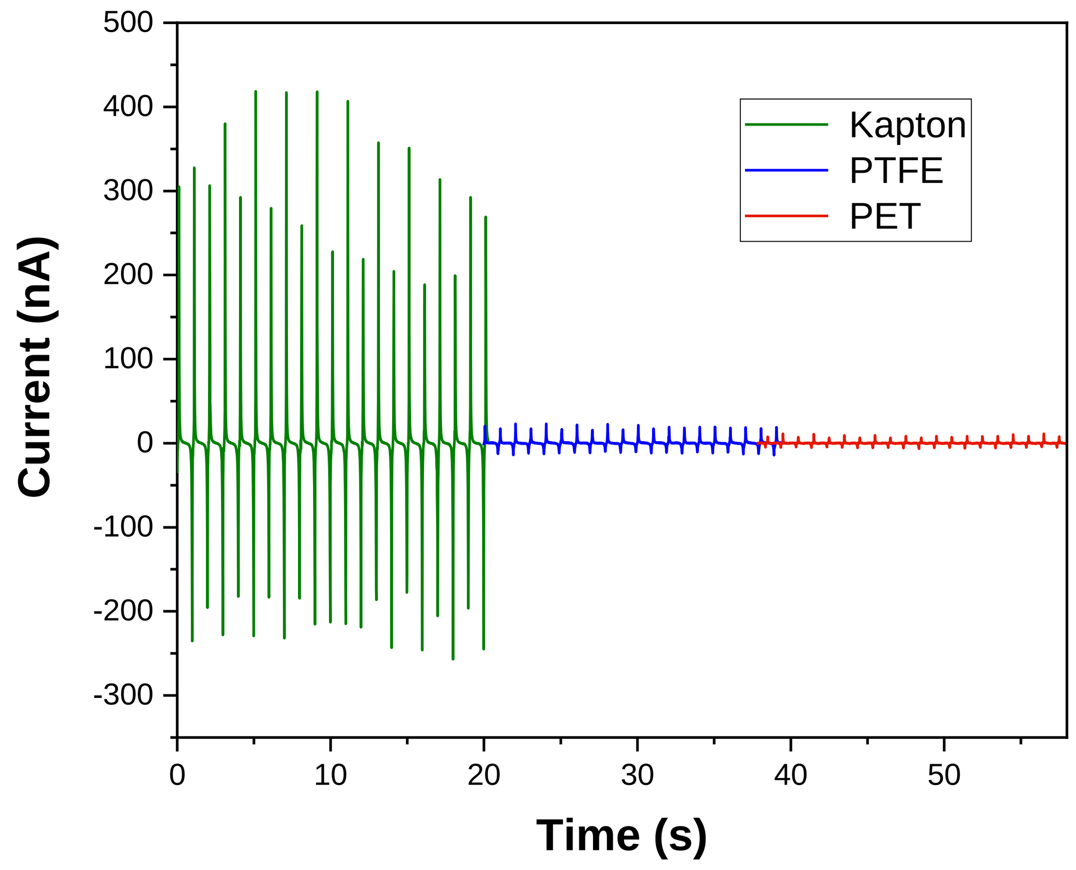
Components:

1. Green nylon
2. Heat transfer film (HTF)
3. Multi-layer graphene
4. Beeswax (2%)
5. Polytetrafluorethylene (PTFE)
6. Copper

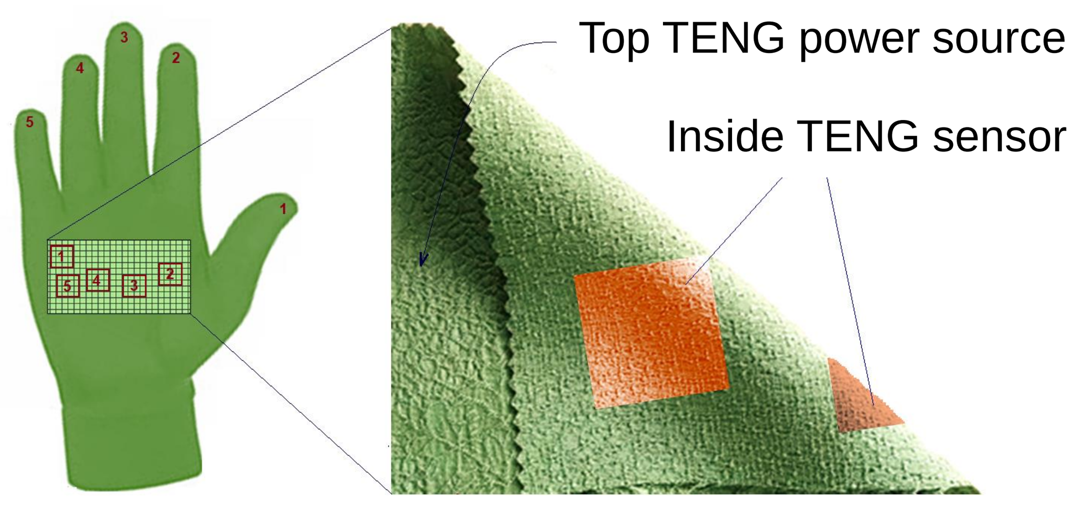
Open-circuit voltage output



Short-circuit current output



Perspective: smart-glove integrated with TENG



Conclusions:

The device showed an open-circuit voltage of 25 V and short-circuit current of 400 nA when stimulated at a 1 Hz frequency. The output can be significantly higher (up to 5-10 times) when compared to devices with a size of 3x3 cm. The power density output of 0.01 W/cm^2 under a load of 62 kΩ was achieved, which is approximately 60 times over that of planar rigid graphene-based TENG. These results pave the way to the potential of solution-processed graphene for low-cost flexible triboelectric devices for harvesting ambient vibration energy.

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